TYPE I PROGRESS REPORT - NUMBER 7

Period: January 1, 1974, to February 28, 1974

INVENTORY OF FOREST AND RANGELAND AND DETECTION OF FOREST STRESS

GSFC Identification Number AG-014, MMC-226

Contract Number S-70251-AG

Report date - March 20, 1974

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TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
Type I-7		

4. Title and Subtitle	5. Report Date
TYPE I PROGRESS REPORT Inventory of Forest and Rangeland and Detection of Forest Stress	March 20, 1974 6. Performing Organization Code
7. Author(s) Robert C. Heller, Robert C. Aldrich, Richard S. Driscoll, F. P. Weber	8. Performing Organization Report No. FS-I-7
9. Performing Organization Name and Address Forest Service, U. S. Dept. of Agriculture Pacific Southwest Forest & Range Exp. Station P. O. Box 245 Berkeley, California 94701	10. Work Unit No. 11. Contract or Grant No. S-70251-AG
12. Sponsoring Agency Name and Address Edward Crump, Technical Monitor Code 430, GSFC Greenbelt, Maryland 20771	13. Type of Report and Period Covered Type I-Progress Report Jan. 1 - Feb. 28, 1974 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract Request for Proposals (RFP) were sent out to 28 prospective vendors for processing ERTS-1, MSS bulk data tapes for all three test sites. The proposals were evaluated for technical competency and an award will be made after negotiations before March 26.

In a controlled experiment on ERTS color composites of forest and rangeland scenes in Colorado, photo interpreters could only separate forest from nonforest. This is the simplest level of classification known as Regional in an ecological classification system called "ECOCLASS." At the Series level only 60-67 percent of the five major forest types could be correctly identified and is not acceptable. Four grassland classifications could be identified within a range of 50 to 100 percent at the Series level of ECOCLASS. Again these levels of accuracy are not considered suitable for broad rangeland mapping.

The first computer processing of stress scenes in South Dakota is being undertaken and peripheral type maps and black and white prints made for comparison with the human classifications. Computer programs for processing DCS/DCP data have been completed and tested. Correlation of scene radiance from ground measurements with ERTS scene radiance as recorded on the CCT's will be used for possible adjustment during computer processing of MSS tapes.

17. Key Words (Selected by Author(s))	18. Distribution Statement
Forest inventory; land use; forest stress; rangeland inventory	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
None	None	~~13~~ 14	4.00

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Atlanta Test Site (Forest Inventory) 226B

Coinvestigator: Robert C. Aldrich

GSFC Identification Number AG-014

Principal Investigator - Robert C. Heller

STATEMENT OF PROBLEMS:

1. Some color composites for images required in our analysis have not been received.

Scene Number	Date Originally Ordered	Date Reordered
1265-15503	May 25, 1973	February 26, 1974
1299-15385	July 19, 1973	February 26, 1974
1336-15441	September 25, 1973	February 26, 1974

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

1. We have started a photo interpretation test to evaluate ERTS bulk photographic data for classifying forest land. In this test we are using color composites enhanced and scaled to 1:1,000,000 overlays on an I^2S additive color viewer. Color photographs were produced using photographic techniques developed in our laboratory and reported previously. Color composites for ERTS scene 1084-15440 (October 15, 1972), 1264-15445 (April 13, 1973), and 1336-15441 (June 24, 1973) are being used to examine 329 random locations. These locations are part of the 400 originally selected during ERTS prelaunch photo preparations. Each of three interpreters will examine the points simultaneously on October and April images using an Old Delft scanning stereoscope. Following this they will reexamine the prints on the April and June images. The results will be analyzed for significant differences between interpreters (3), land-use classes (8), and seasonal combinations (2).

2. Work continued on unsupervised clustering procedures and procedures for stratifying data directly into land-use classes, rather than spectral types. Maps stratifying six land classes have been produced for two

10,000-acre areas from CCT's for scene 1084-15440 (October 15, 1972). Procedures developed are now producing maps for the same two areas using CCT's for scene 1264-15445 (April 13, 1973).

WORK PLANNED FOR NEXT REPORTING PERIOD:

1. Complete photo interpretation test for forest classification using seasonal ERTS data.

2. Continue developing photographic keys to illustrate land use and forest classifications by season.

3. Continue computer classifications and assessments of computer mapping accuracy.

SIGNIFICANT RESULTS: None

PUBLICATIONS: Aldrich, R. C. 1974. Detecting disturbances in the forest environment. Paper presented at ASP-ASCM National meeting, St. Louis, Mo. March 11-15, 1974.

RECOMMENDATIONS FOR CHANGES: Because of problems in acquiring data needed for our analysis, we have requested a two-month extension of our contract completion date (see Heller's letter to James M. Higgins, Contracting Officer, dated February 27, 1974).

STANDING ORDER FORM CHANGES: None

ERTS IMAGE DESCRIPTOR FORMS: None

DATA REQUEST FORM CHANGES: None

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Manitou Test Site (Rangeland Inventory) 226C

Coinvestigator: Richard S. Driscoll

GSFC Identification Number AG-014

Principal Investigator: Robert C. Heller

STATEMENT OF PROBLEMS:

1. We have received all but one of the retrospectively ordered bulk color composites of the Manitou Test Site 226C. This product, I.D. 1334-17142, is a key item since this is one of two prime scenes that is planned for contract processing.

2. The laborious task of ground truth point transfers from topographic maps to aircraft and ERTS photographs is alleviated with the accession of the Zoom Transfer Scope on March 6, 1974.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

1. Controlled visual interpretation of the color composite of ERTS scene 1028-17135 is nearly complete. Three testing procedures have been established for this process: (1) differentiation of forest versus nonforest classes--the Regional level of ECOCLASS, (2) differentiation within forest classes--the Series level of ECOCLASS, and (3) differentiation within nonforest classes--the Series level of ECOCLASS. Regarding interpretive characteristics, apparent image color was the only image characteristic we could define with any degree of precision using prelocated training cells--areas that had been ground-checked, photointerpreted with aircraft photography, and precision located on the ERTS frame.

Apparent color was difficult to establish to a standard base, even using the ISCC-NBS standard color notations. For example, at the Series level, Douglas-fir, lodgepole pine, and spruce/fir forests all equate mostly to dark purplish red (Color 259). However, there is sufficient color difference in grassland versus forest elements to discriminate between the two units, except between the aspen forest class and the wet meadow class. For these two units, the color class was ISCC-NBS Color 11 (very red).

Interpretation to the Regional ECOCLASS level indicated that the forest as a class was interpreted 100 percent correctly and nonforest as a class was interpreted 94 percent correctly. Commission errors in the nonforest class occurred when the aspen class and the wet meadow class occurred side-by-side and the wet meadow class was interpreted as aspen forest.

Correct interpretation to the Series level within each Regional level and the results to date are summarized below:

Class Order	% Correct Identification
Forests	
Aspen	64
Douglas-fir	67
Lodgepole pine	67
Ponderosa pine	60
Spruce/fir	63
Grassland	
Mountain bunchgrass	50
Shortgrass	81
Wet herbaceous meadow	78
Wet shrubby meadow	100

With the exception of two classes, wet shrubby meadow and shortgrass, visual interpretation of ERTS-1 imagery secured at the peak of the growing season to the Series level does not yet appear to be at an acceptable level of accuracy. There are at least three reasons for this low accuracy: (1) plant community mixing at their edges where they grade gradually into each other results in a gradation of apparent image signatures and results in complex decision making on what to class the object, (2) the variable slope degree and aspect as it affects the signature, and (3) for forest classes especially, and to an extent the grassland classes, the confounding effects of amount of plant-crown cover (density) and ground surface material in the scene.

2. Preliminary results of computer interpretation of the MAN-A Unit of the Manitou test site have been obtained. This is being done under a Cooperative Aid Agreement with the Department of Earth Resources, Colorado State University by Dr. James A. Smith. The following matrix is based on training set selection and analyses of 40,401 pixels using RECOG.

	BUNCH	CLOUD	CLOUDSH	DOUG	PONDER	WILLOW	WMEADOW	TOTAL	ACCURACY
BUNCH [1]	122	0	0	21	64	59	19	285	43%
CLOUD	0	465	0	0	0	0	0	465	100%
CLOUDSH	2	1	507	0	1	0	2	513	99%
DOUG	7	0	0	96	6	7	5	121	79%
PONDER	41	0	0	5	94	47	11	198	48%
WILLOW	1	0	0	0	3	24	0	28	89%
WMEADOW	5	0	0	9	2	6	14	36	39%
TOTAL	178	466	507	131	170	143	51		
FALSE ALARM	31%	0%	0%	27%	45%	83%	73%		

[1] BUNCH = Mountain Bunchgrass
CLOUD = Cloud
CLOUDSH = Cloud Shadow
DOUG = Douglas-fir
PONDER = Ponderosa Pine
WILLOW = Wet Shrubby Meadow
WMEADOW = Wet Herbaceous Meadow

It is noted that although the accuracy of classification of some classes is high, the false-alarm rate on the same classes is also high. This is probably due to an edge effect of the training and testing set boundaries and is related to the gradual gradation from one class category to another as they actually exist in the real world. The MAN-A Unit is notorious for this condition; many of the classes are small relative to pixel size and the chance of boundary errors in training set selection is high. We are reconciling the problem by: (1) more precise selection of training sets by transposing training set areas validated on aerial photographs to digital MSS gray-scale maps and (2) selection of training sets external to the MAN-A subsample block and applying them to the MAN-A classification. The assumption is that training set selection external to the area under test produces closely correlated signature statitstics to the test area.

SIGNIFICANT RESULTS:

Controlled visual interpretation of one ERTS-1 scene taken at the peak of the growing season has indicated that classification to the ECOCLASS Series level is not entirely satisfactory. For five forest classes--aspen, Douglas-fir, lodgepole pine, ponderosa pine, and Spruce/fir--correct identification ranged from 60 to 67 percent. With the exception of shortgrass and wet shrubby meadow classes in the nonforest categories (81 and 100 percent correct, respectively), correct identification of the nonforest classes is so far unacceptable. The low accuracies are believed due to (1) edge effects due to ecotones between plant community classes with apparent similar image characteristics, (2) confounding effects of amount of plant crown cover and ground surface material in the scene, and (3) variable land slope degree and aspect as it affects the image signature.

PUBLICATIONS: None

RECOMMENDATIONS FOR CHANGE: None

STANDING ORDER FORM CHANGES: None

ERTS IMAGE DESCRIPTOR FORMS: 44 total submitted

DATA REQUEST FORM CHANGES: None

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Black Hills Test Site (Forest Stress) 226A

Coinvestigator: F. P. Weber

GSFC Identification Number AG-014

Principal Investigator - Robert C. Heller

STATEMENT OF PROBLEMS:

After an initial brisk exchange of processing MSS aircraft data and some first iteration color film imagery, we have received no final processed results of Mission 213 multispectral scanner imagery. Our analysis of the final data products will take 2 weeks and therefore must be delivered to Berkeley not later than April 20, 1974, to be included as results in the ERTS-1 final contract report.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

1. A total of five proposals for processing ERTS-1 multispectral scanner data were received by the contract awards panel: (a) Honeywell, (b) Laboratory for Applications of Remote Sensing (LARS), (c) University of Kansas, (d) University of California at Berkeley, and (e) Georgia Institute of Technology. The selection panel determined that Honeywell presented the best technical proposal and that although the LARS proposal was somewhat less responsive to the Forest Service RFP, it was deemed technically acceptable. The other three proposals were determined to be technically unacceptable.

The Laboratory for Applications of Remote Sensing (LARS) at Purdue University was awarded the contract for processing ERTS-1 multispectral scanner data as a result of negotiations between the Forest Service contracting officer, Honeywell, and LARS. The final negotiated contract price was $19,702 for the following tasks:

To process five separate ERTS-1 multispectral scanner scenes according to the specifications established in Sections 210, 220, 230, 240, and 250 of the Forest Service RFP.

Black Hills scene 1028-17121, of August 20, 1972
Black Hills scene 1047-17175, of September 8, 1972
Georgia scene 1084-15440, of October 16, 1972

Georgia scene 1264-15445, of April 13, 1973
Colorado scene 1388-17134, of August 15, 1973

2. The approach to the processing the ERTS-1 multispectral scanner bulk data tapes has changed since the original proposal was conceived; therefore, we have made necessary adjustments in handling the Black Hills ecoclassification system. For the purpose of all analyses, i.e., human photo interpretation, in-house computer processing, and subcontracted processing, the Black Hills test site has been divided into two major blocks:

a. Spearfish Canyon Block--88,087 acres

N44°24'00" - 104°00'00"W
N44°24'00" - 103°48'00"W
N44°12'00" - 103°48'00"W
N44°12'00" - 104°00'00"W

b. Lead Block--102,036 acres

N44°24'00" - 103°52'00"W
N44°24'00" - 103°37'30"W
N44°12'30" - 103°37'30"W
N44°12'30" = 103°52'00"W

Computer training is performed within three subblocks, each about 10,000 acres in size. The three subblocks have been carefully type-mapped using three levels of 1972 color infrared resource photography: (a) 1:32,000 scale (USFS), (b) 1:55,000 scale (NASA), and (c) 1:110,000 (NASA). Type-mapping was performed at a scale of 1:32,000; however, decisions on type line boundaries were made with the aid of the two smaller scales of photography. The problems with nonalignment of boundaries between adjoining photographs was adjusted using a black-and-white print of the 1:110,000 photographs (one required for each subblock). The photographic print was enlarged to 1:24,000 scale as was the acetate overlay of the preliminary type map. Boundary types were adjusted onto a second acetate overlay which became the new adjusted type map. The classification which was used in the type-mapping is as follows:

Ecological class

00 Dead ponderosa pine (subclassification shown under Spot size below)
01 Healthy ponderosa pine; 0 to 50 percent crown closure
02 Healthy ponderosa pine; 51 to 100 percent crown closure
03 Predominantly hardwood; up to 25 percent pine
04 Grassland wet (cultivated or natural, usually on water course)
05 Grassland dry (cultivated or natural, well drained)

06 Bare soil and rock outcroppings

07 Water

08 Transition: soil and rock with sparse vegetation including burned areas, logging areas, etc.

Spot size (METERS) for ecological class 00

00 Less than 10 meters

01 10 to 25 meters

02 26 to 50 meters

03 51 to 100 meters

04 101 to 300 meters

05 Greater than 300 meters

In the case of both of our computer mapping efforts (in-house Forest Service and subcontracted at LARS), the type-maps of the subblocks will be used to train the classifier and to check on the validity of preprocessing corrections, i.e., geometric, axis rotation, and radiance. The test of the two computer classification and mapping algorithms will be the reliability of the signature extension from the training subblocks to the classification and mapping of the two major blocks.

A very careful technique has been devised for determining the accuracy of the final Forest Service and LARS-produced classification maps. A total of 243 point samples have been precisely located, on a one-by-one mile grid, within the two Black Hills blocks. The points have been classified using large-scale resource photographs and rectified 1:32,000-scale composites of the major blocks. These systematically located points are supplemented by the ecoclass point samples listed on page 21 of Type II report, number 3, issued January 1974. The latter points were selected to specifically represent each of the components of the established Black Hills ecosystem classification and will provide a balance to the accuracy evaluation.

3. Forest Service processing of the ERTS-1 MSS tapes of two Black Hills scenes has progressed to the stage of having produced "gray-scale" maps in color of each of the three subblocks with the EAI plotter. These unrectified maps were used for locating the corner pixels of each of the subblocks.

4. The following list of interpretation aids has been developed for use in the final ERTS-1 analysis for the Black Hills:

a. Black and white templates for human interpretation

(1) 1:250,000-scale type map for each of the three subblocks
(2) 1:1,000,000-scale type map for each of the three subblocks
(3) 1:250,000 interpretation grid with the major block boundaries indicated
(4) 1:1,000,000-scale interpretation grid with the major block boundaries indicated

b. Black and white prints and templates for computer classification

(1) 1:22,000-scale black-and-white prints of each subblock
(2) 1:24,000-scale black-and-white prints of each subblock
(3) 1:32,000-scale black-and-white mosaic print of both blocks
(4) 1:22,000-scale type map of each subblock
(5) 1;24,000-scale type map of each subblock
(6) 1:32,000-scale type map of each subblock
(7) 1:32,000-scale interpretation grid for locating the 243 point samples on the final computer classification maps of each block.

c. Black and white and color prints for general interpretation aids

(1) 1:1,000,000-scale, channel 5, black-and-white prints of three Black Hills scenes.
(2) 1:250,000-scale channel 5, black-and-white prints of three Black Hills scenes with block and subblock boundary annotations.
(3) 1:100,000-scale, channel 5, black-and-white prints of three Black Hills scenes with block and subblock boundary annotations.
(4) 1:1,000,000-scale, channel 4, 5, and 7, color mosaics of three Black Hills scenes, each with a template overlay for block and subblock boundary location.

5. The following computer programs have been completed and tested for processing DCS/DCP data:

a. ERTSDCS--which processes raw DCS data and converts it to voltages while formating the data by DCP channel, platform, identification, Julian date, and satellite pass.

b. DCSDATA--which processes raw DCS data which has been multiplexed and converts it to voltages while formating the data by multiplex level, DCP channel, platform identification, Julian date, and satellite pass.

c. DCSCAL--which converts voltages to calibrated engineering units, i.e., radiance in mWATTS . $STER^{-1}$ CM^{-2}, while formating the data by sensor location (i.e., healthy pine site) and measurement parameter (i.e., scene radiance, MSS channel 5).

A fourth program DCSANL is still under development to fully analyze the energy relationships measured at each of the instrumented test sites.

Program HIST is now being tested to provide radiance distribution counts for each of the ERTS-1 MSS channels from the bulk data tapes. Eventually, this data will be used to correlate radiance values of scene types from throughout the Black Hills test site to scene radiance values measured on the ground.

Program PLOFS is complete and is being used to display the results of the analyses in program DCSANL. PLOFS provides a CALCOMP plotter output suitable for use directly in the ERTS-1 final report.

Program BUGLO is still being developed at this time. When complete it will provide for tabulation of photo interpretation results, and will provide the coordinate locations, infestation size class, and total number of bark beetle-infested pine within the boundary of any given management rectangle of the Black Hills test site, given the four corner coordinates of the management rectangle.

WORK PLANNED FOR THE NEXT REPORTING PERIOD:

1. We will complete the in-house Forest Service MSS processing of three Black Hills scenes (same two as in contract processing plus 1334-17124) and perform the accuracy determination on the final classification maps of the two major blocks.

2. We will complete our human photo interpretation of the three Black Hills scenes using the Zoom 70 microscope and the VARISCAN viewer. The classification maps derived from the human interpretation will be tested for accuracy against the 243 point grid by the same procedure as the computer classification maps.

3. We will complete the analysis of DCS/DCP-transmitted instrumentation data to determine seasonal variations in scene radiance as affected by weather and habitat conditions.

4. We will complete the correlation of scene radiance data measured on the ground with that extracted from the bulk data tapes, and determine, if possible, the effect of atmospheric influences on satellite scene radiance values.

5. We will complete the analysis of the final DAS-produced digital photographs of the 24-channel MSS, Mission 213 data. We wish to determine the effect of field-of-view, spectral combinations , and aircraft altitude on the correlations of digital classification of beetle-killed trees with the ground truth counts of dead trees for subblock 2.

SIGNIFICANT RESULTS: None

PUBLICATIONS: None

RECOMMENDATIONS FOR CHANGES: None

STANDING ORDER FORM CHANGES: None

ERTS-1 IMAGE DESCRIPTOR FORMS: None

DATA REQUEST FORM CHANGES: None